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(71) Applicant(s)

**Fichtel & Sachs AG**

**(Incorporated in the Federal Republic of Germany)**

**Ernst-Sachs-Strasse 82, 97419 Schweinfurt,  
Federal Republic of Germany**

(72) Inventor(s)

**Gerhard Tebbe**

(74) Agent and/or Address for Service

**Barker, Brettell & Duncan**

**138 Hagley Road, Edgbaston, BIRMINGHAM,  
B16 9PW, United Kingdom**

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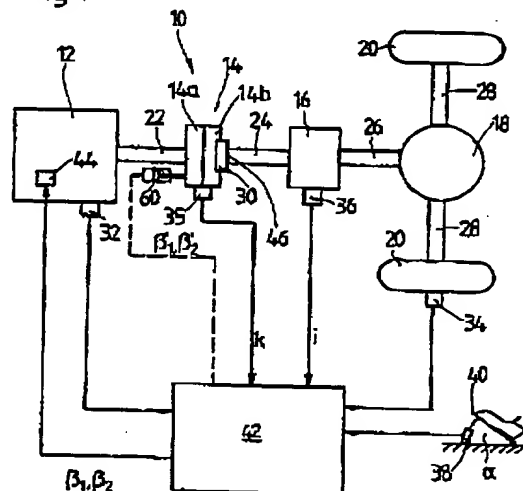
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**ONLINE: CLAIMS, JAPIO, WPI**

**(54) Altering torque in a drive train of a motor vehicle.**

(57) Altering torque in a drive train 10 of a motor vehicle can lead to vibrations in the drive train. To minimise such vibrations, when a torque change is required, eg by operation of throttle pedal 40, a computing device 42 computes the value of the adjusting magnitude required for an adjusting member such as injector 44 to produce the torque change. The computing device then splits the adjusting magnitude value into a first partial value and at least one further partial value and determines at least one time dependent on the operating state of the drive train 10 such that, if the partial values are applied at intervals separated by that time, at least partial destructive interference of vibrations of the drive train will be produced. A control device 54 then controls the adjusting member 44 initially on the basis of the first partial value, and then, after the determined time, on the basis of a further partial value. Operation of the clutch may alternatively be controlled.

**Fig.1**



**GB 2 305 743 A**

Fig.1

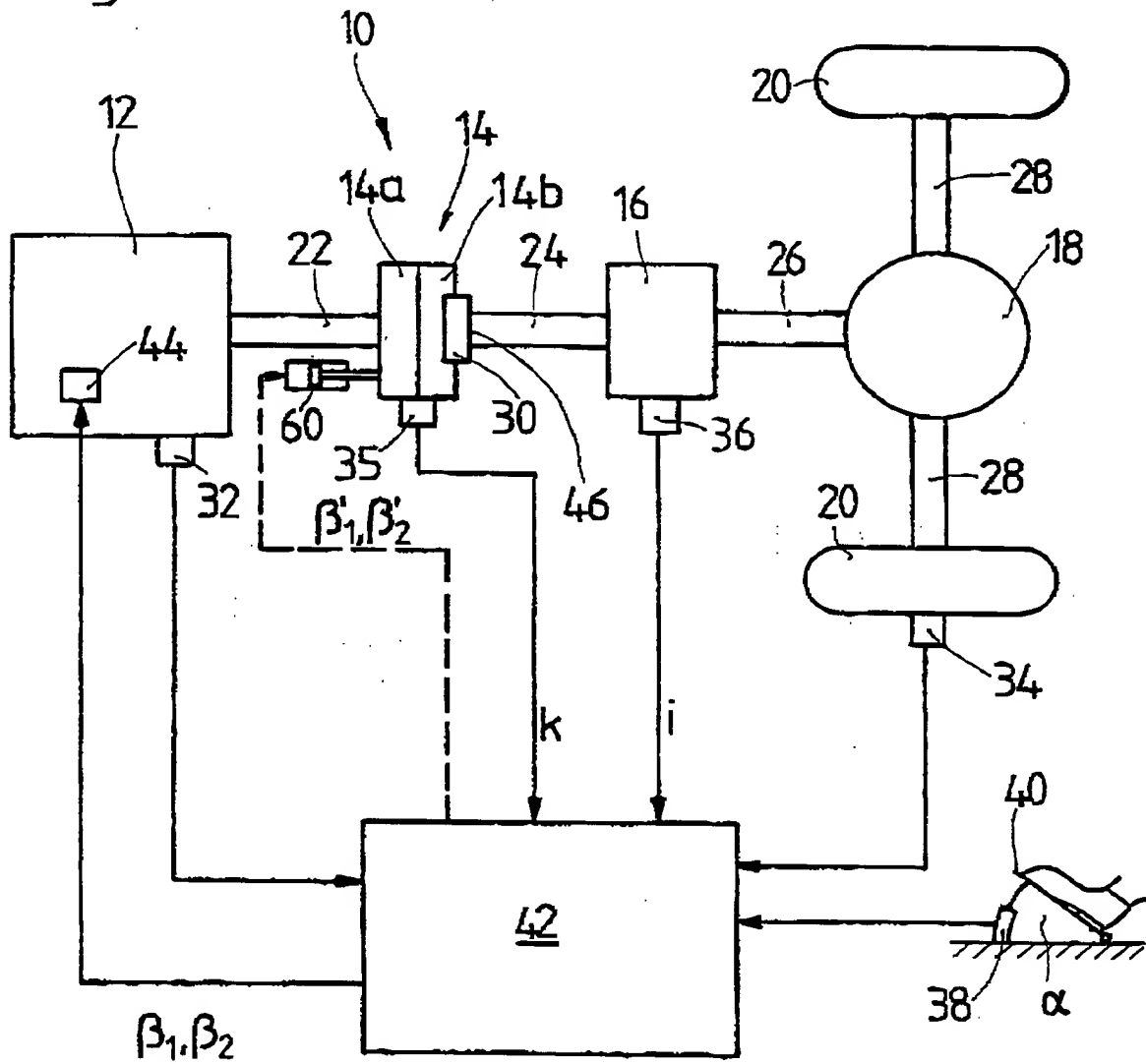


Fig. 2

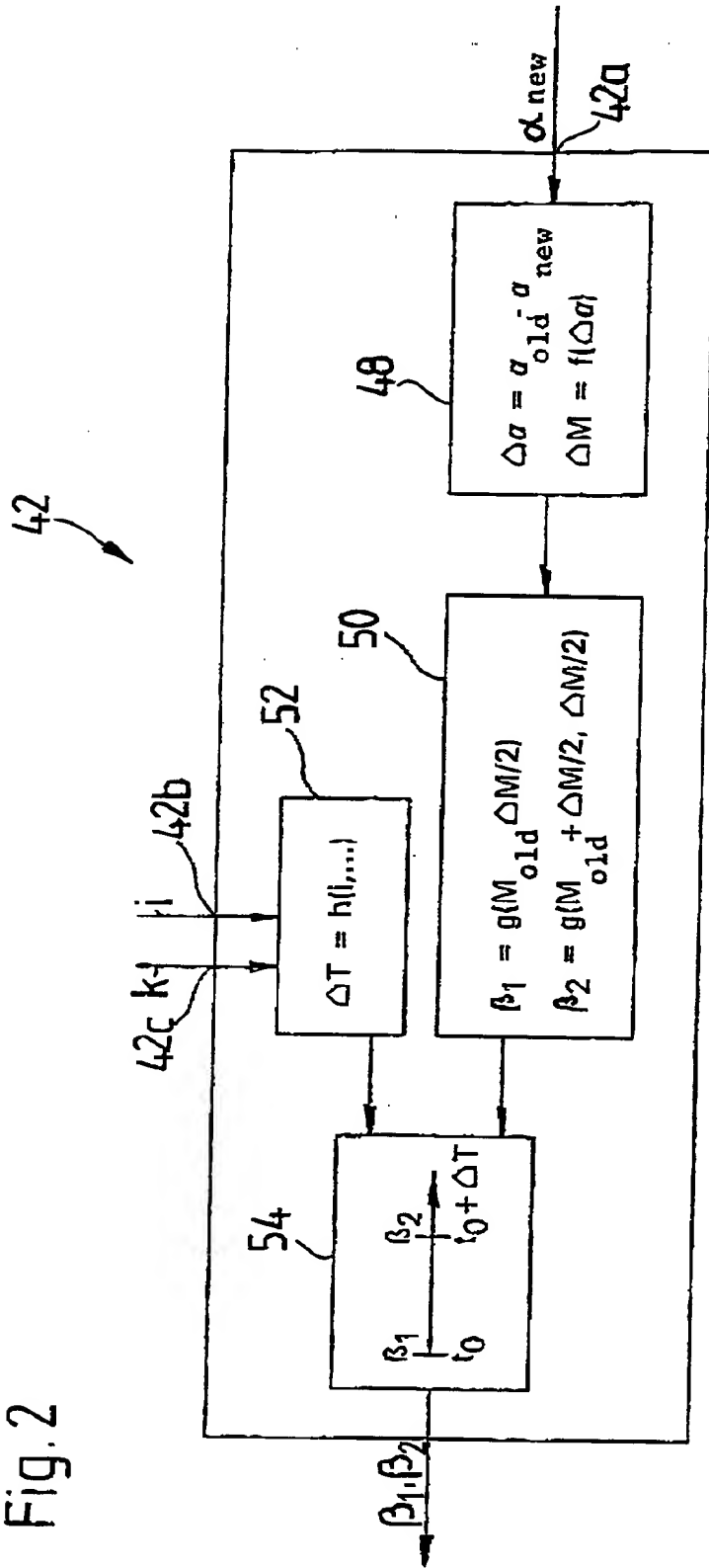


Fig. 3

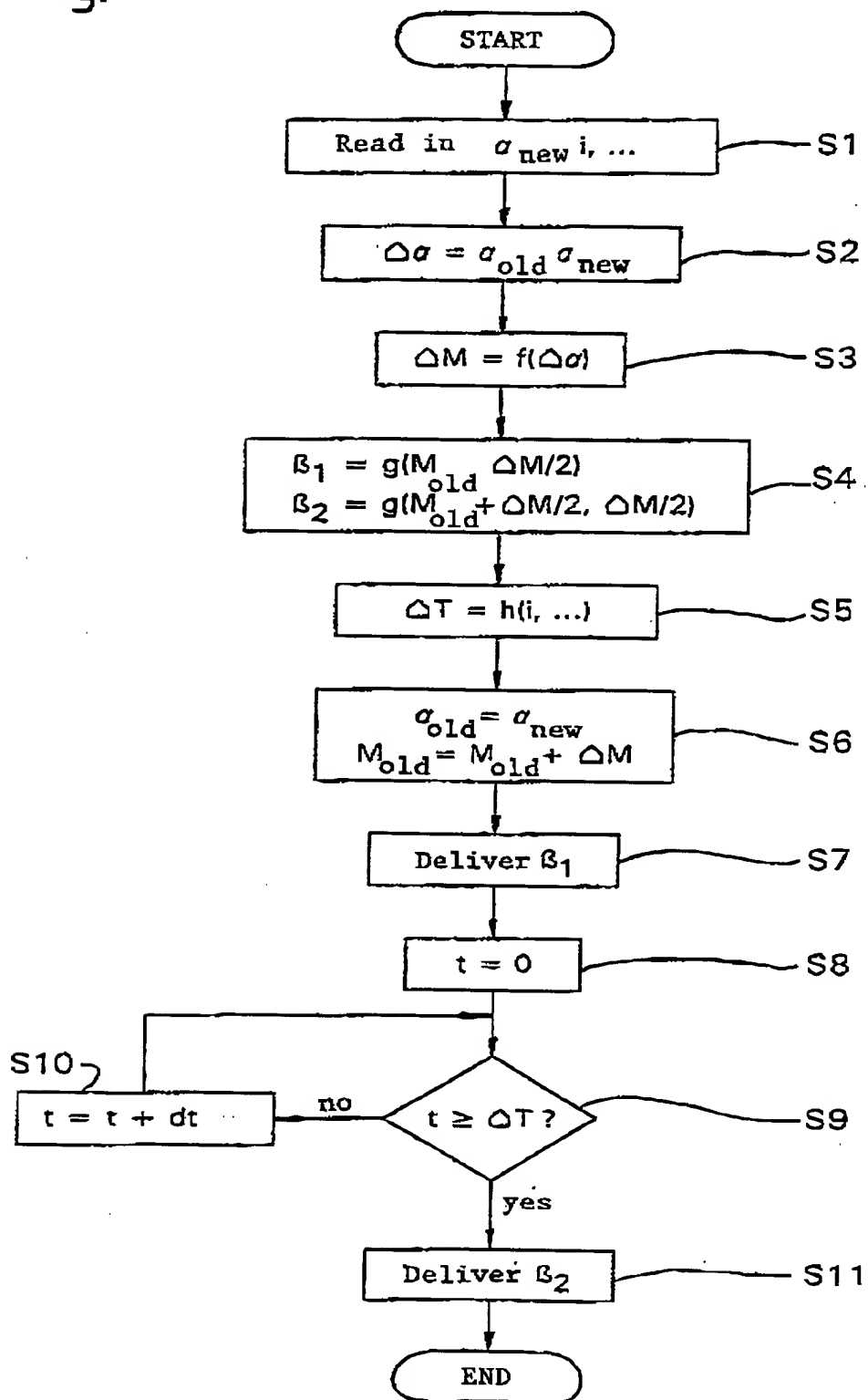
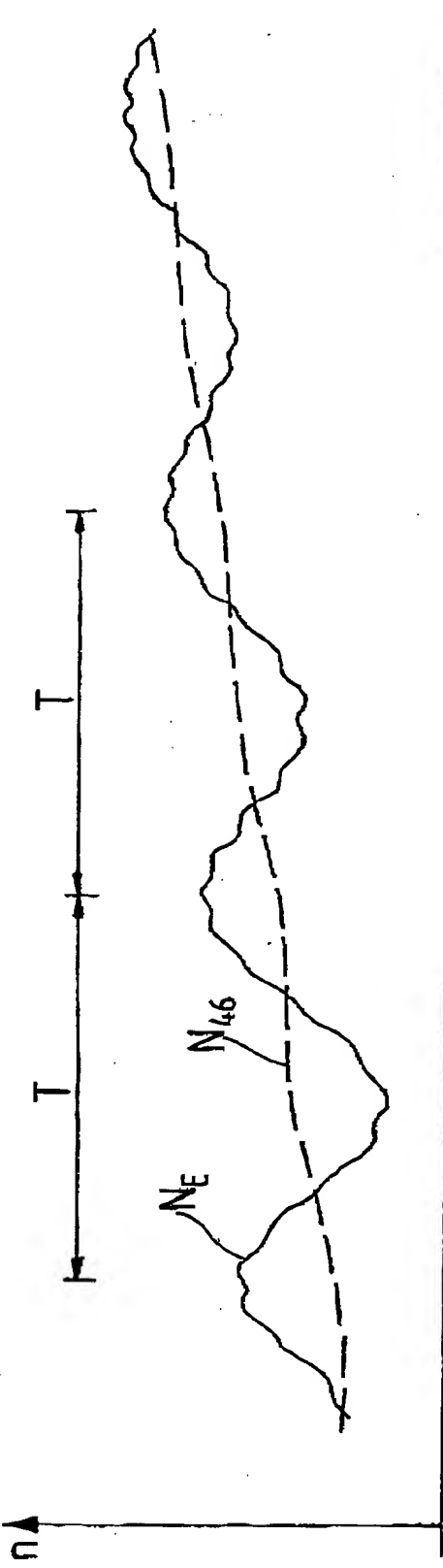


Fig. 4a



4 / 7

Fig. 4b

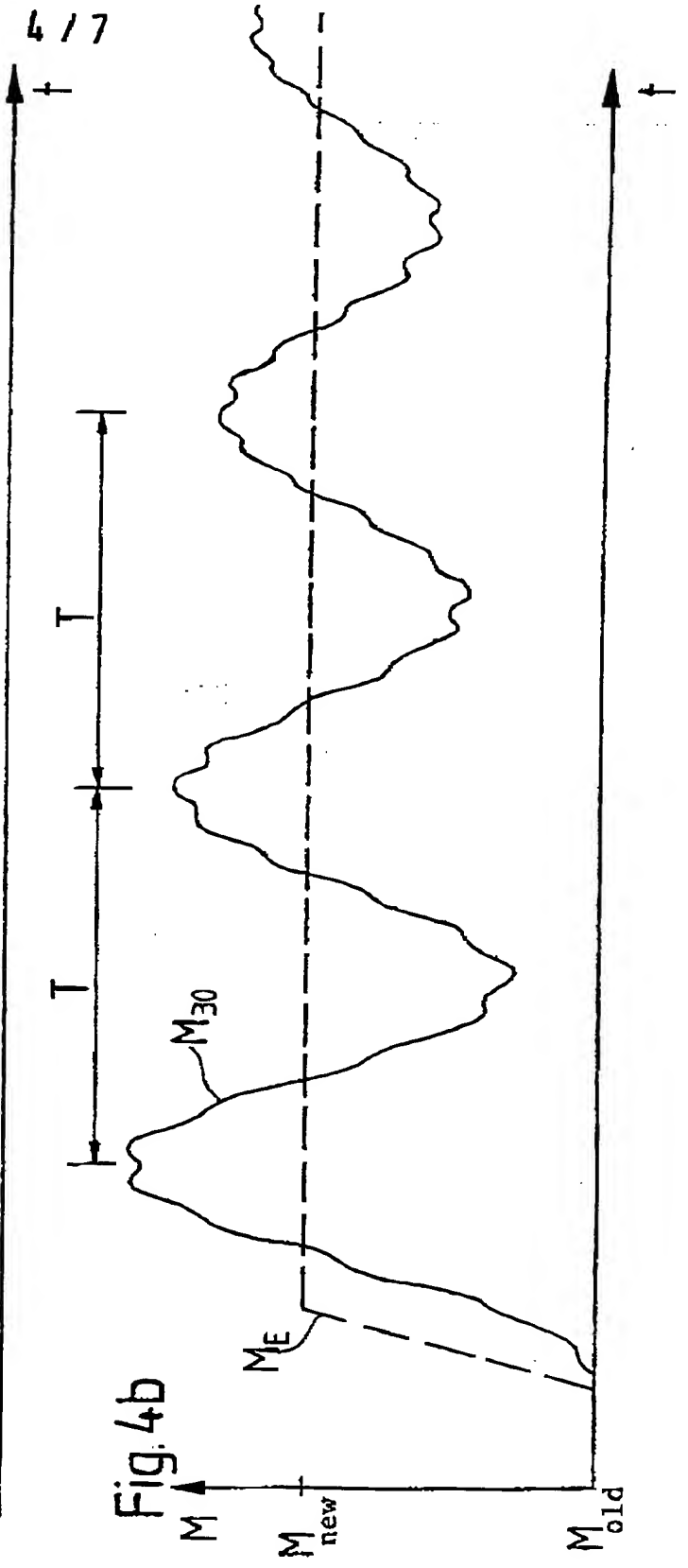


Fig. 5a

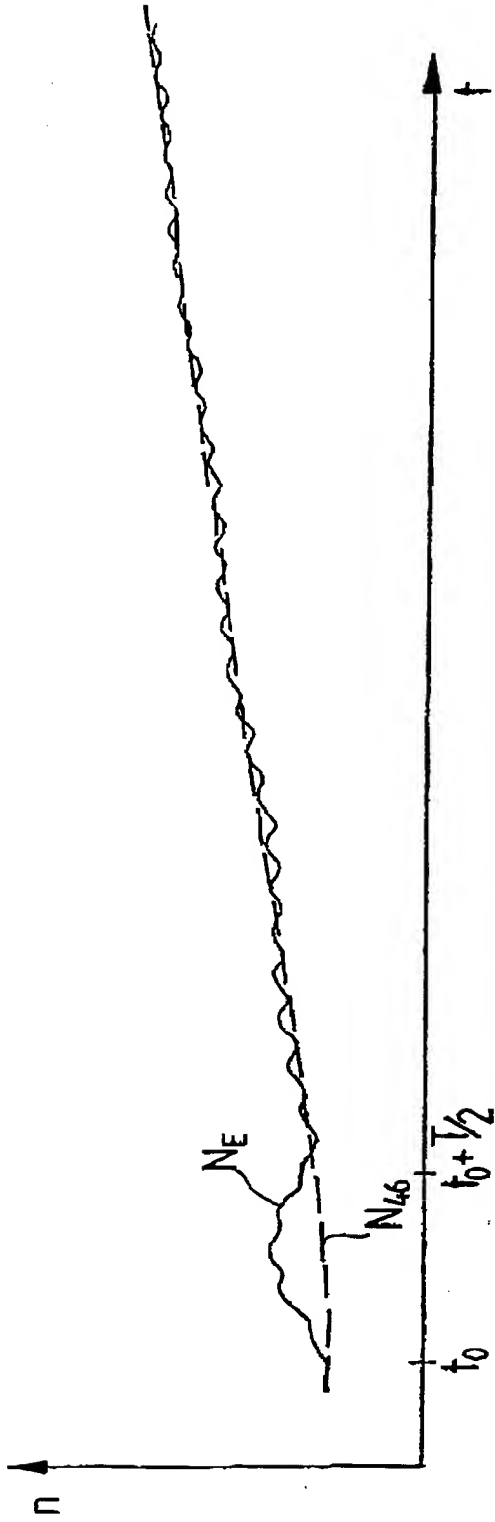


Fig. 5b

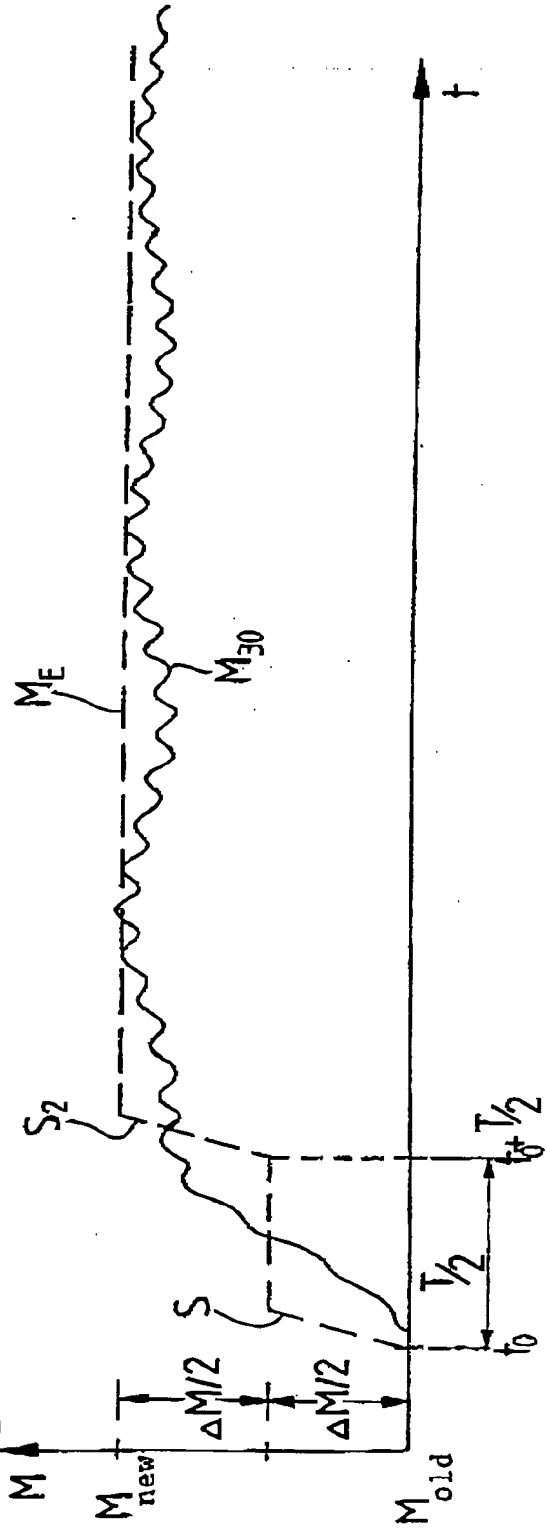


Fig. 6a

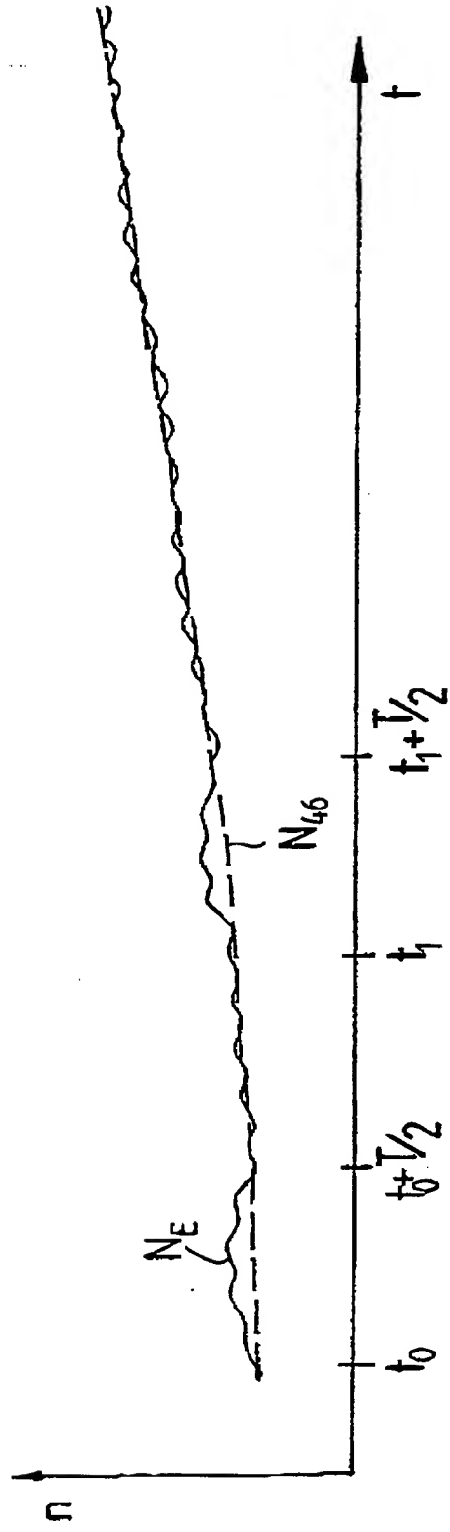
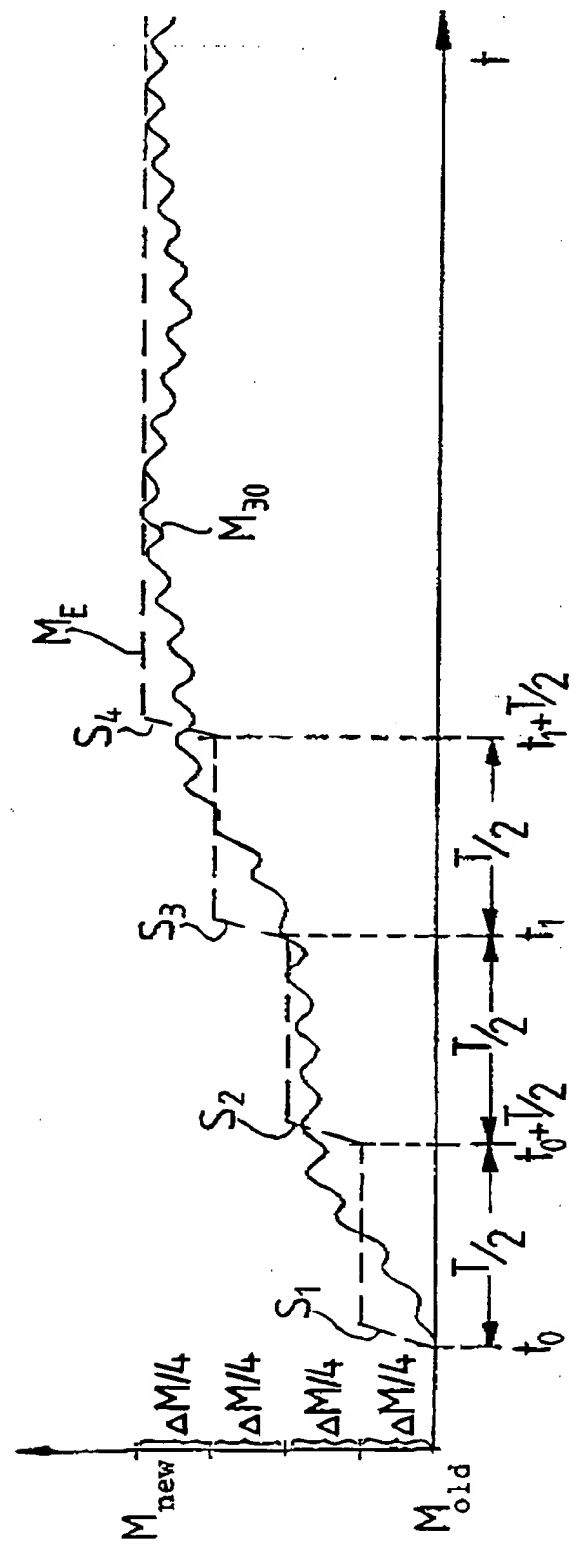
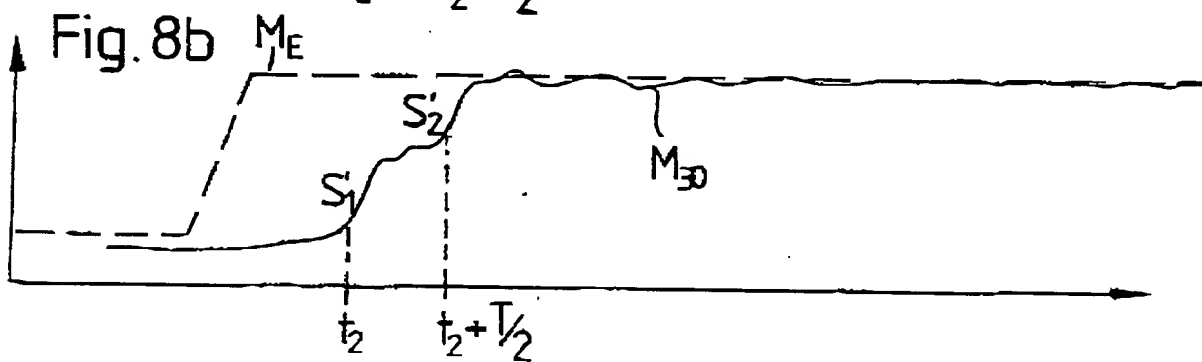
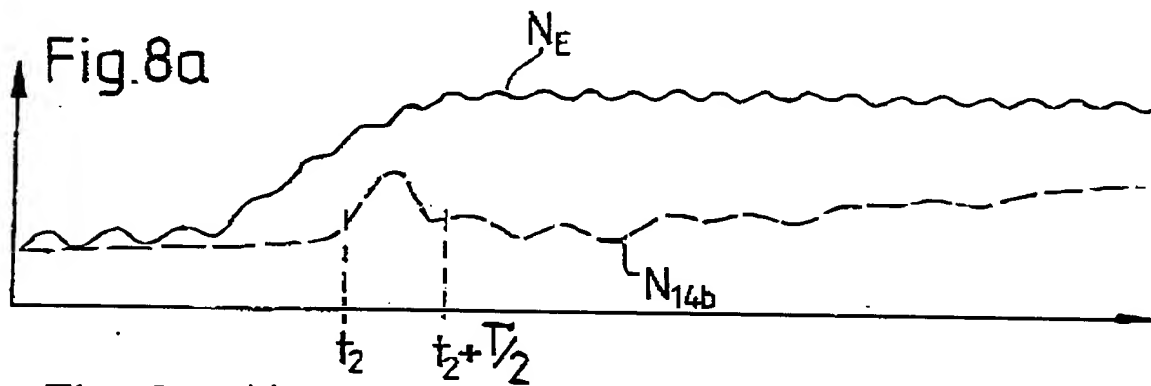
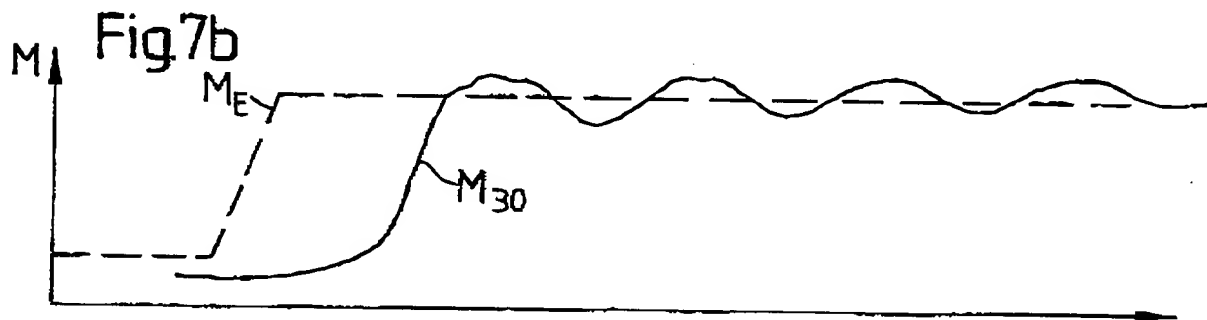
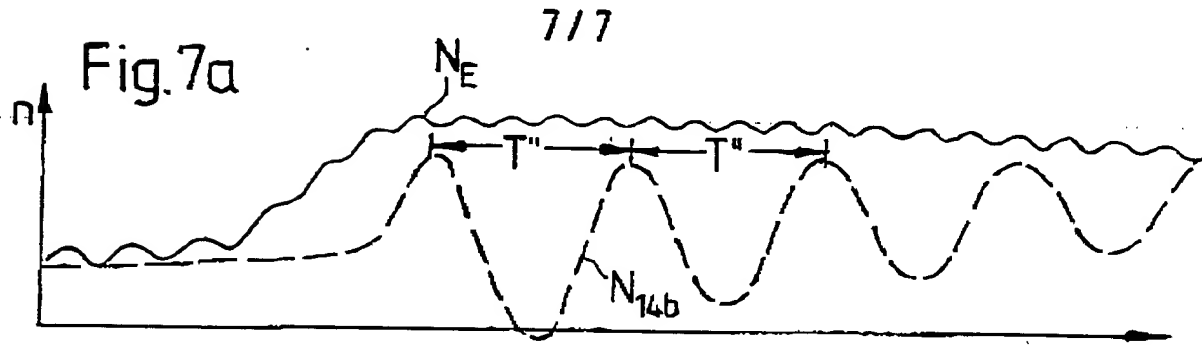


Fig. 6b







**METHOD AND APPARATUS FOR ALTERING THE TORQUE IN A  
DRIVE TRAIN OF A MOTOR VEHICLE**

The invention relates to a method and apparatus for altering a  
5 torque in a drive train of a motor vehicle.

The invention aims to alter the useful torque, which is to be  
understood as meaning a torque which is necessary for the drive train to  
fulfil its function of driving the vehicle. The useful torques are in  
10 particular the driving torque generated by a drive unit - internal-  
combustion engine or electric motor - and a transmission torque of a  
clutch arranged in the drive train of the vehicle. The present invention  
will be discussed in the following in terms of altering the driving torque,  
but without restricting the subject matter of the application to this.

15

The drive train of a motor vehicle is made up of masses and  
elasticities which together form vibrating systems. A change in the  
driving state of the vehicle, for example an acceleration of the vehicle,  
requires an alteration of the driving torque generated by the engine or  
20 motor of the vehicle. The change in torque and consequent alteration in  
load excites the drive train of the vehicle into load changing vibration  
because of resonance, and in fact primarily at the lowest natural frequency  
of the whole vibrating system. With the clutch engaged this is the entire  
drive from the engine to the driving wheels.

25

The prior art shows a number of ways to avoid or reduce such  
load-changing vibrations. In one known method an adjusting member  
acting on the useful torque is not controlled directly on detecting a driving  
state of the vehicle indicating the desired change in useful torque. On the  
30 contrary a delay circuit is used to introduce an adjusting magnitude of the

contrary a delay circuit is used to introduce an adjusting magnitude of the adjusting member progressively to match the altered driving state. The aim is to keep the alteration in useful torque acting on the drive train per unit time below a predetermined value so that the amplitude of the vibrations resulting from this alteration in the torque remains low and the damping members in the drive train are able to damp these vibrations adequately. As a consequence of the time delay, however, the vehicle does not respond to a useful torque demand with sufficient rapidity. This is a drawback, for example during an overtaking manoeuvre, which requires immediate acceleration of the vehicle.

It is an aim of the present invention to provide a method and apparatus for altering the useful torque in a drive train which can react to a useful torque demand substantially without any time delay and avoid the build-up of vibrations in the drive train at least partially.

According to a first aspect of the present invention, a method of altering a useful torque in a drive train of a motor vehicle comprises the steps of

detecting an operating state of the vehicle;

determining the value of an adjusting magnitude for at least one adjusting member acting on the drive train of the vehicle in dependence on the detected operating state of the vehicle;

splitting the value of the adjusting magnitude into a first partial value and at least one further partial value;

determining at least one time interval in dependence on an operating state of the drive train for at least partial destructive interference of drive train vibrations produce by the changes in useful torque of the basis of the partial values; and

controlling the or each adjusting member first on the basis of the first partial value of the adjusting magnitude and then after the or each time interval on the basis of the corresponding further partial value of the adjusting magnitude.

5

Each of the control movements of the adjusting member on the basis of one of the partial values of the adjusting magnitude produces a change in useful torque which excites the drive train of the vehicle into vibration. However, these excitations of the drive train take place at different times. With the time period between the individual excitations determined in dependence on the driving state of the drive train on which the current natural frequency of the drive train depends, the vibrations generated by the excitations cancel one another out at least partially and preferably almost completely.

15

The natural frequencies of the drive train of the vehicle typically lie in the order of magnitude of 4 - 10 Hz. This results in values for the time delay between the individual excitations of an order of magnitude of 0.05 - 0.1 seconds. If the first partial alteration of torque is introduced directly on detection of the demand for useful torque on the basis of the first partial value, the full alteration of torque on the basis of the further partial values is obtained after a very short time interval, that is to say virtually without any delay. Because of the destructive interference of the vibrations arising from the individual excitations the drive train, after the introduction of the desired change in torque, is almost vibration-free. Any vibrations that are still present can be damped by the usual torsional vibration dampers present in the drive train, the constructional requirements on these vibration dampers being significantly reduced by the introduction of the method according to the invention by virtue of the minimal amplitude of the residual vibrations.

30

Preferably the value of the adjusting magnitude is split into an even number of partial values. Most preferably it is split into two partial values. In this way the control of the or each adjusting member can be simplified, in particular when the partial values are associated in pairs. Then, for determining the time intervals not all the individual excitations need to be considered simultaneously, but on the contrary it is sufficient to look at each pair of associated partial values independently of the remaining partial values.

10

When the useful torques acting on the drive train as a result of control by the adjusting member on the basis of a pair of partial values are of substantially the same amount, then a suitable choice of the time interval between the excitations generated by the two partial values results in a substantially complete destructive interference between the two excitations. As already indicated, to obtain substantially complete destructive interference of the excitations, the time interval between the control operations of the adjusting member on the basis of a pair of partial values should correspond to an odd multiple of half the vibration period of the natural frequency of the drive train. Preferably the time interval is equal to half the vibration period of the natural frequency of the drive train.

15  
20

In order to keep the amplitude of the vibrations initially generated in the drive train to a value below a predetermined threshold, control of the adjusting member on the basis of a first pair of partial values is completed before control of the adjusting member on the basis of further partial values is introduced. In this way it is possible to ensure that a first pair of excitations has been cancelled out before the first excitation of a further pair of excitations is introduced into the drive train.

25  
30

If a delayed alteration of the useful torque is desired as a result of a predetermined operating state of the vehicle, but with a delay independent of the operating state of the drive train, the time interval  
5 between control operations of the adjusting member on the basis of two successively partial values of different pairs is determined in dependence on a predetermined time delay.

For both the driving torque of the vehicle engine and the  
10 transmission torque of the vehicle clutch, the operating state of the vehicle can be determined on the basis of the position of a throttle lever or throttle pedal.

The operating state of the drive train may be determined on the  
15 basis of the currently engaged gear in a gearbox of the vehicle. In fact the natural frequency of the drive train alters according to which gear is engaged, because of the different gearbox components involved in the drive train.

20 The adjusting member can for example be an actuating member producing a driving torque in the drive train. In the case of a motor vehicle having an internal-combustion engine, it may be an actuating motor for the throttle valve or for a fuel injection valve. In this case the quantity of fuel being fed to the engine, in particular the quantity injected,  
25 is used as the adjusting magnitude.

Alternatively, the adjusting member may be an actuating member producing a transmission torque in the drive train. It may be an actuating member producing the engaging force of an actuating element of the  
30 vehicle clutch, the engaging force being used as the actuating magnitude.

A method which has the aim of reducing the vibrations arising in the drive train as a result of a change in torque is known from DE-A-36 16 768, but this does not fall within the scope of the invention.

5 In the known method the vibrations which occur are detected and on the basis of the detection signal an additional rotary mass provided in the drive train is controlled to be switched in or disconnected from it. This additional rotary mass produces an additional torque which opposes the vibrations in the drive train. The drive train provided to carry out this

10 method has a complicated construction because of the additional rotary mass.

The invention also relates to apparatus for altering a useful torque in the drive train of the motor vehicle.

15

According to a second aspect of the invention, apparatus for altering a useful torque in a drive train of a motor vehicle comprises a sensing device for detecting an operating state of the vehicle, a computing device for computing the value of an adjusting magnitude for at least one

20 adjusting member affecting the useful torque in dependence on the detected operating state of the vehicle, a splitting device for splitting the value of the adjusting magnitude into a first partial value and at least one further partial value, a time-interval-setting device for determining at least one time interval in dependence on an operating state of the drive train

25 detected by at least one further sensing device for at least partial destructive interference of drive train vibrations produced by the changes in useful torque on the basis of the partial values, and a control device for controlling the or each adjusting member first on the basis of the first partial value of the adjusting magnitude and then after the or each time

interval on the basis of the corresponding further value of the adjusting magnitude.

5 The advantages of the apparatus, and of the further features set out below, are substantially the same as those for the corresponding method of the invention.

10 Preferably, the splitting device splits the value of the adjusting magnitude into an even number of partial values. Most preferably, it is split into two values. The partial values are then associated in pairs.

The useful torques acting on the drive train as a result of control by the adjusting member on the basis of a pair of partial values are preferably of substantially the same amount.

15

Conveniently the time-interval-setting device determines a time interval between the control operations of the adjusting member on the basis of a pair of partial values as an odd multiple of half the vibration period of the natural frequency of the drive train. The time interval is  
20 preferably equal to half the period.

25 Preferably the control device completes control of the adjusting member on the basis of a first pair of partial values before introducing control on the basis of the further partial values. The time-interval-setting device sets the time interval between control operations on the basis of two successive partial values of different pairs in dependence on a predetermined time delay.

30 The sensing device for detecting the operating state includes a throttle-lever or throttle-pedal position sensor. The further sensing device

for detecting the operating state of the drive train may include a gear sensor for detecting the currently engaged gear of a gearbox of the vehicle.

- 5        The adjusting member may be an actuating member producing a driving torque in the drive train, for example a fuel injection valve. Alternatively the adjusting member may be an actuating member producing a transmission torque in the drive train. It may then be an actuating member generating the engaging force between a pressure plate  
10      and a clutch plate of the vehicle clutch.

Both aspects of the invention are illustrated by way of example in the accompanying drawings, in which:-

- 15        Figure 1 shows apparatus according to the invention;

Figure 2 is a block circuit diagram explaining the construction of the central processing unit illustrated in Figure 1;

- 20        Figure 3 is a flow diagram for explaining the method according to the invention;

- 25        Figures 4a and 4b are graphs showing the relationship of engine speed and vehicle speed (Figure 4a) and mean engine torque and a torque (Figure 4b) in a torsion damper in the drive train where the method according to the invention is not used;

- 30        Figures 5a and 5b are graphs similar to Figures 4a and 4b for a two-stage increase in torque in accordance with the method of the invention;



Figures 6a and 6b are graphs similar to Figures 4a and 4b for a four-stage increase in torque in accordance with the method of the invention;

5

Figures 7a and 7b are graphs showing the relationship of engine speed and clutch plate speed (Figure 7a), and engine torque and a torque (Figure 7b) in a torsion damper in the clutch, where the clutch reacts to a rise in the engine torque with a momentary state of slip and the transmission torque of the clutch is increased in a single step to the value corresponding to the new engine torque; and

10

Figures 8a and 8b are graphs similar to Figures 7a and 7b but where a two-stage alteration of the transmission torque of the clutch is used in accordance with the method of the invention.

15

In Figure 1 the drive train of a motor vehicle is indicated generally at 10. The drive train comprises an internal combustion engine 12, a clutch 14, a gearbox 16, a differential 18, driving wheels 20 and connecting shafts 22, 24, 26 and 28. The shaft 22 connects the engine 12 to the clutch 14, the shaft 24 connects the clutch 14 to the gearbox 16, the shaft 26 connects the gearbox 16 to the differential 18, and the shafts 28 connect the differential 18 to the wheels 20. The clutch 14 comprises a pressure plate 14a and a clutch plate 14b, which is connected to the shaft 24 through a torsional vibration damper 30. The construction and operation of the clutch 14 and of the torsional vibration damper 30 are known in themselves and will not be explained further here.

25

The drive train 10 also has various sensors for detecting the operating state of the vehicle. A speed sensor 32 detects the speed of rotation  $N_E$  of the engine 12. A vehicle speed sensor 34 at the wheels 20 detects the road speed of the vehicle. A clutch state sensor 35 detects whether the clutch 14 is disengaged, is in a state of slip or is engaged. A gear sensor 36 detects which gear is engaged in the gearbox 16. The gearbox 16 can be manually operated or automatic. A throttle pedal sensor 38 detects the position of the throttle pedal 40 of the vehicle. The output signals of the sensors 32, 34, 35, 36 and 38 are fed to a central processing unit 42, shown in more detail in Figure 2.

When the driver of the vehicle wants the vehicle to accelerate and so presses down on the throttle pedal 40, the central processing unit 42 detects the driver's requirement for acceleration from the throttle pedal signal  $\alpha$  fed to it. The central processing unit 42 uses the value of the signal  $\alpha$  to determine the quantity of fuel to be fed to the engine 12 through fuel injection valve 44 (only one such valve is illustrated in Figure 1), corresponding to the increased torque required by the driver. The central processing unit 42 transmits a corresponding signal to the injection valve 44.

If the torque  $M_E$  of the engine 12 changes from the old torque value  $M_{old}$  to the new value  $M_{new}$  in a single step as a consequence of this signal, as illustrated in the broken-line curve in Figure 4b, a vibration is produced in the drive train 10. This vibration may be a variation in the engine speed  $N_E$  and of the torque  $M_{30}$  arising at the torsion damper 30. These two variations ( $N_E$  and  $M_{30}$ ) are illustrated respectively in full lines in Figures 4a and 4b, and comprise low-frequency load-change vibrations with a period  $T$ , on which is superimposed a higher frequency vibration originating from the working stroke of the engine 12. These load-change

vibrations can also be clearly seen following the torsion damper 30, as shown in Figure 4a in conjunction with the speed  $N_{46}$  of the connecting shaft 24 detected at 46 ahead of the gearbox 16, and illustrated in broken lines in Figure 4a.

5

To avoid such load-change vibrations, in accordance with the invention, the change in the driving torque  $M_E$  is not carried out in a single step, but in several steps. This is explained in conjunction with the splitting of the torque change  $\Delta M$  into two steps.

10

In order to perform this splitting, the central processing unit 42 shown in Figure 2, receives the throttle pedal position signal  $\alpha_{\text{new}}$  from the throttle pedal sensor 38 at a first input 42a. A torque-change-computing unit 48 computes from the difference

15  $\Delta\alpha = \alpha_{\text{old}} - \alpha_{\text{new}}$  of the position of the throttle pedal 40 the change  $\Delta M$  in the driving torque  $M_E$  of the engine 12 required by the driver, using a transfer function  $f$ , and supplies an appropriate signal to an analysing device 50. The analysing device 50 computes from the torque change  $\Delta M$  two control values for the injection valve 44 using a transfer function  $g$ . A

20 first control value  $\beta_1$  leads to the driving torque  $M_E$  of the engine 12 being increased from the former value  $M_{\text{old}}$  by the amount  $\Delta M/2$ . Then, on the basis of the control signal  $\beta_2$  starting from the instantaneous value  $M_{\text{old}} + \Delta/2$  the engine torque  $M_E$  is further increased by the amount  $\Delta M/2$ . Therefore, the setting of the new torque value  $M_{\text{new}} = M_{\text{old}} + \Delta M$  takes

25 place in two equal steps  $\Delta M/2$ , due to the splitting of the torque change into the partial values  $\beta_1, \beta_2$ .

In addition, the central processing unit 42 receives at a second input 42b a signal  $i$  from the gear sensor 36 which tells it which gear is

30 engaged in the gearbox 16. This gear signal  $i$  and a clutch state signal  $k$

received at the input 42c (there may be others as well), are fed to a time-interval-setting device 52 which determines from these signals, using a transfer function  $h$ , a time interval  $\Delta T$ . As load-change vibrations in the drive train 10 chiefly involve vibrations of the lowest natural frequency of the drive train, the time-interval-setting device initially  
 5 determines the vibration period  $T$  of this lowest natural frequency on the basis of the received gear information  $i$ , the state  $k$  of the clutch 14, the vehicle type and the like. In order to achieve substantially complete cancellation by destructive interference of the load-change vibrations  
 10 originating from the two torque steps  $S_1$  and  $S_2$  (see Figure 5b), these must be of opposite phase. If a substantially uninterrupted increase in the torque is to be achieved the second torque-increasing step  $S_2$  must accordingly be introduced into the drive train half a vibration period of the natural frequency of the drive train 10, i.e. the time interval  $T/2$ , after  
 15 the first step  $S_1$ . Accordingly the time interval  $\Delta T$  is chosen to be equal to  $T/2$  ( $\Delta T = T/2$ ).

The control values  $\beta_1$  and  $\beta_2$  and the time interval  $\Delta T$  are fed to a control device 54 of the central processing unit 42 which acts on the  
 20 injection valve 44 directly at time  $t_0$  of detection of the increased torque demand by the driver on the basis of the control value  $\beta_1$  and then, after the passage of the time interval  $\Delta T$ , on the basis of the second control value  $\beta_2$ .

25 The operation of the control device 54 results in a two-stage increase in the driving torque  $M_E$  of the engine illustrated in broken lines in Figure 5b from the previous engine torque  $M_{old}$  to the new engine torque  $M_{new}$ .

As shown in Figure 5a in the full line of the engine speed  $M_E$ , engine 12 is caused to vibrate by the first step  $S_1$  of the torque increase at time  $t_0$ . The further excitation by the second step  $S_2$  at time  $t_0 + T/2$  interferes destructively with the initial load-change vibration so that there is substantial cancellation of the load-change vibration. The torque  $M_{30}$  (shown in full lines in Figure 5b) of the torsional vibration damper 30 has a significantly reduced amplitude of vibration in comparison with Figure 4b. Finally, the speed  $N_{46}$  (illustrated in broken lines in Figure 5a) shows practically no vibration.

10

The method explained above is operated by the central processing unit 42 on the basis of the flow diagram shown in Figure 3. In a step  $S_1$  the central processing unit 42 reads the signals fed to it from the various sensors. On the basis of the throttle pedal signal  $\alpha_{new}$  fed to it and of a position signal  $\alpha_{old}$  received in the preceding cycle the change in position  $\Delta\alpha$  of the pedal 40 is determined in step  $S_2$ . Using the transfer function  $f$  of the central processing unit 42 determines in step  $S_3$  from the throttle pedal change  $\Delta\alpha$  the change  $\Delta M$  in the driving torque of the vehicle required by the driver of the vehicle. In step  $S_4$  two control values  $\beta_1$  and  $\beta_2$  for the injection valve 44 are determined from the previous driving torque  $M_{old}$  and the required change  $\Delta M$  in the driving torque. In step  $S_5$ , using a transfer function  $h$ , the time interval  $\Delta T$  is computed from the sensed gear position of the gearbox 16 and if necessary further parameters. The control values  $\beta_1$  and  $\beta_2$  are delivered to the injection valve 44 separated by the interval  $\Delta T$ . In step  $S_6$  a memory (not shown) in the central processing unit 42, is prepared for the next cycle in the program. In step  $S_7$  the control value  $\beta_1$  is delivered to the injection valve 44 and in step  $S_8$  a timer is zeroed to the value  $t = 0$ . In step  $S_9$ , there is a check on whether the time interval  $\Delta T$  has already run out. If this is not the case, the timer continues to run in a further step  $S_{10}$ . Then, when the time

30

interval  $\Delta T$  runs out the control value  $B_2$  is delivered to the injection valve 44 in step  $S_{11}$ .

Although the method and the apparatus according to the invention  
 5 have been described in an example of a two-step increase in torque with destructive superposition of the excitation of the drive train 10 arising from these two steps, it is equally possible to split the overall change in torque  $\Delta M$  into more than two steps, for example three or more steps. Splitting into an even number of steps is preferred as each two steps can  
 10 then be associated in pairs together to provide a destructive superposition of the load-change vibrations arising from them.

Figures 6a and 6b show an example where the torque change  $\Delta M$  is split into four steps. At time  $t_0$  the engine torque  $M_E$  (illustrated in broken  
 15 lines in Figure 6b) is increased in a first step  $S_1$  by an amount  $\Delta M/4$ . The engine speed  $N_E$  (illustrated in full lines in Figure 6a) shows the occurrence of the load-change vibrations excited by this first step  $S_1$ . At time  $t_0 + T/2$  the second step  $S_2$  is performed, to provide a further increase in torque of  $\Delta M/4$ , and to introduce further load-change  
 20 vibrations into the drive train 10 in opposite phase to those from the step  $S_1$ . The engine speed  $N_E$  (Figure 6a) shows that the load-change vibrations are virtually completely cancelled. This process is then repeated in the steps  $S_3$  and  $S_4$  at time  $t_1$  and  $t_1 + T/2$ . Figure 6a shows first the build up of load-change vibrations at time  $t_1$  and then their  
 25 cancellation by the step  $S_4$  at time  $t_1 + T/2$ .

It will be noted that the amplitude of the load-change vibrations in the engine speed behaviour  $N_E$  in Figure 6a is smaller than the two-step excitation of Figure 5a. However the new engine torque  $M_{new}$  required by  
 30 the driver is achieved later, at time  $t_1 + T/2$ . However, under certain

operating conditions of the vehicle this can be desirable. The splitting into four steps has the further advantage that the time interval  $T'$  between the steps  $S_2$  and  $S_3$  can be chosen as desired. It is only the pairs of steps  $S_1$  and  $S_2$ , and  $S_3$  and  $S_4$  that need to be associated with each other to provide destructive interference of the load-change vibrations that they generate. The time-period-setting device 52 can accordingly freely select the time  $T'$  depending on the current operating state of the vehicle, in order to carry out the required increase in torque in a manner and form suited to this operating condition.

10

If the operating condition of the vehicle requires a very slow alteration in the engine torque, the vibrations generated for the destructive interference of associated steps, for example  $S_1$  and  $S_2$ , can be chosen to be equal to an odd multiple of half the period of vibration  $T$  of the natural frequency of the drive train.

15

It will also be noted that the separate pairs of steps, for example  $S_1$  and  $S_2$  on the hand and  $S_3$  and  $S_4$  on the other hand, can produce different torque changes. Thus, the steps  $S_1$  and  $S_2$  could produce a torque change of  $0.6 \cdot \Delta M$ , whilst the steps  $S_3$  and  $S_4$  produce a torque change of  $0.4 \cdot \Delta M$ . For destructive interference what is important is simply that each of a pair of steps produces substantially the same torque change.

20

Although the method has been described in conjunction with an increase in the driving torque  $M_E$  of the engine 12 of the vehicle, it will be understood that the method can also be used for a reduction in the driving torque of the engine 12, such as arises for example on engine braking when the driver takes his foot off the throttle pedal 40.

25

The method and the apparatus according to the invention have been explained above as an example of a change in the driving torque of the engine 12. However, they can also be used for a reduction of so-called "snatching vibrations" arising in the clutch 14. In motor vehicles  
5 equipped with an electronic clutch system (EKS) the engaged condition of the clutch 14 is controlled from the central processing unit 42 of the electronic clutch system by means of an actuating member 60. The actuating member 60 is shown in Figure 1 in the form of a hydraulic actuating device.

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In certain operating states of the vehicle it can be advantageous when using an electronic clutch system for the engaging force exerted by the actuating member 60 on the pressure plate 14a of the clutch 14 against the clutch plate 14b not to be increased simultaneously with an increase in  
15 the driving torque of the engine 12. This means that the clutch 14 remains firmly engaged, but initially permits a certain amount of slip between the pressure plate 14a and the clutch plate 14b. The engaged state is restored later by a time-delayed increase in the engaging force exerted by the actuating member 60. However, an increase in the engaging force  
20 also results in an increase in the transmission torque of the clutch 14 and this torque change can also lead to vibrations in the drive train 10, namely the snatching vibrations mentioned above. As the pressure plate 14a and the clutch plate 14b are not firmly coupled together in this arrangement the part of the drive train 10 relevant in considering the natural frequency  
25 of these snatching vibrations starts at the clutch plate 14b. The natural frequencies of the snatching vibrations therefore are higher than the natural frequencies of the load vibrations, usually in the range from 10 to 20 Hz.



When the engaging force of the pressure plate 14a against the clutch plate 14b is increased by the actuating member 60 in a single step by the necessary value, the snatching vibrations shown in Figure 7a occur in the speed  $N_{14b}$  of the clutch plate 14b. These snatching vibrations are shown in broken lines in Figure 7a. The snatching vibrations are also clearly shown in the torque  $M_{30}$ , (illustrated in full lines in Figure 7b), exerted on the torsional vibration damper 30. The period of the snatching vibrations is  $T''$ .

When the increase in engaging force of the pressure plate 14a against the clutch plate 14b by the actuating member 60 is split into two steps  $S_1'$  at time  $t_2$  and  $S_2'$  at time  $t_2 + T''/2$  (see Figure 8b), then the first step  $S_1'$  of the increase in engaging force produces at time  $t_2$  a snatching vibration which can clearly be seen in Figure 8a in  $N_{14b}$ , (illustrated in broken lines), the speed of the clutch plate 14b. The second step  $S_2'$  of the increase in engaging force is in opposite phase to this snatching vibration of the first step  $S_1'$  and so introduces a further snatching vibration into the system, which cancels the first substantially completely. This can be seen in the clearly reduced amplitude of the speed  $N_{14b}$  of the clutch plate 14b (illustrated in broken lines in Figure 8a) and of the torque  $M_{30}$  at the torsional vibration damper 30 (illustrated in full lines in Figure 8b).

In this embodiment, the central processing unit 42 transmits to the actuating member 60 the two control signals  $\beta_1'$  and  $\beta_2'$  separated in time by the amount  $T''/2$ .

## CLAIMS

1. A method of altering a useful torque in a drive train of a motor vehicle comprises the steps of
- 5 detecting an operating state of the vehicle;
- determining the value of an adjusting magnitude for at least one adjusting member acting on the drive train of the vehicle in dependence on the detected operating state of the vehicle;
- splitting the value of the adjusting magnitude into a first partial
- 10 value and at least one further partial value;
- determining at least one time interval in dependence on an operating state of the drive train for at least partial destructive interference of drive train vibrations produce by the changes in useful torque of the basis of the partial values; and
- 15 controlling the or each adjusting member first on the basis of the first partial value of the adjusting magnitude and then after the or each time interval on the basis of the corresponding further partial value of the adjusting magnitude.
- 20 2. A method as claimed in claim 1, in which the value of the adjusting magnitude is split into an even number of partial values.
3. A method as claimed in claim 1 or claim 2, in which the value of the adjusting magnitude is split into two partial values.
- 25 4. A method as claimed in claim 2 or claim 3, in which the partial values are associated in pairs.

5. A method as claimed in claim 4, in which the useful torques acting on the drive train as a result of control by the adjusting member on the basis of a pair of partial values are of substantially the same amount.
- 5 6. A method as claimed in claim 4 or claim 5, in which the time interval between the control operations of the adjusting member on the basis of a pair of a pair of partial values corresponds to an odd multiple of half the vibration period of the natural frequency of the drive train.
- 10 7. A method as claimed in claim 6, in which the time interval is equal to half the vibration period of the natural frequency of the drive train.
8. A method as claimed in any preceding claim, in which control of the adjusting member on the basis of a first pair of partial values is  
15 completed before control on the basis of further partial values.
9. A method as claimed in claim 8, in which the time interval between control operations of the adjusting member on the basis of two successive partial values of different pairs is determined in dependence on a  
20 predetermined time delay.
10. A method as claimed in any preceding claim, in which the operating state of the vehicle is determined on the basis of the position of a throttle pedal.
- 25 11. A method as claimed in any preceding claim, in which the operating state of the drive train is determined on the basis of the currently engaged gear of a gearbox of the vehicle.

12. A method as claimed in any preceding claim in which the adjusting member is an actuating member producing a driving torque in the drive train.

5 13. A method as claimed in claim 12, in which a quantity of fuel to be fed to an internal-combustion engine of the motor vehicle is used as the adjusting magnitude.

10 14. A method as claimed in any of claims 1 to 11, in which the adjusting member in an actuating member producing a transmission torque in the drive train.

15 15. A method as claimed in claim 14, in which the engaging force of an actuating element of a clutch of the vehicle is employed as the adjusting magnitude.

20 16. Apparatus for altering a useful torque in a drive train of a motor vehicle comprises a sensing device for detecting an operating state of the vehicle, a computing device for computing the value of an adjusting magnitude for at least one adjusting member affecting the useful torque in dependence on the detected operating state of the vehicle, a splitting device for splitting the value of the adjusting magnitude into a first partial value and at least one further partial value, a time-interval-setting device for determining at least one time interval in dependence on an operating state of the drive train detected by at least one further sensing device for at least partial destructive interference of drive train vibrations produced by the changes in useful torque on the basis of the partial values, and a control device for controlling the or each adjusting member first on the basis of the first partial value of the adjusting magnitude and then after

the or each time interval on the basis of the corresponding further value of the adjusting magnitude.

17. Apparatus as claimed in claim 16, in which the splitting device  
5 splits the value of the adjusting magnitude into an even number of partial values.

18. Apparatus as claimed in claim 16 or claim 17, in which the  
splitting device splits the value of the adjusting magnitude into two partial  
10 values.

19. Apparatus as claimed in claim 17 or claim 18, in which the partial values are associated in pairs.

15 20. Apparatus as claimed in claim 19, in which the useful torques acting on the drive train as a result of control by the adjusting member on the basis of a pair of partial values, are of substantially the same amount.

21. Apparatus as claimed in claim 19 or claim 20, in which the  
20 time-interval-setting device determines a time interval between the control operations of the adjusting member on the basis of a pair of partial values as an odd multiple of half the vibration period of the natural frequency of the drive train.

25 22. Apparatus as claimed in claim 21, in which the time interval is equal to half the vibration period of the natural frequency of the drive train.

23. Apparatus as claimed in any preceding claim, in which the control  
30 device completes control of the adjusting member on the basis of a first

pair of partial values, before introducing control of the adjusting member on the basis of further partial values.

24. Apparatus as claimed in any of claims 16 to 23, in which the  
5 time-interval-setting device sets a time interval between control operations of the adjusting member on the basis of two successive partial values of different pairs in dependence on a predetermined time delay.

25. Apparatus as claimed in any of claims 16 to 24, in which the  
10 sensing device for detecting the operating state of the vehicle includes a throttle-lever or throttle-pedal position sensor.

26. Apparatus as claimed in any of claims 16 to 25, in which the  
15 further sensing device for detecting the operating state of the drive train includes a gear sensor for detecting the currently engaged gear of a gearbox of the vehicle.

27. Apparatus as claimed in any of claims 16 to 26, in which the  
20 adjusting member is an actuating member producing a driving torque in the drive train.

28. Apparatus as claimed in claim 27, in which the adjusting member is a fuel injection valve.

25 29. Apparatus as claimed in any of claims 16 to 26, in which the adjusting member is an actuating member producing a transmission torque in the drive train.

30. Apparatus as claimed in claim 29, in which the adjusting member is an actuating element generating the engaging force between a pressure plate and clutch plate of a clutch of the vehicle.

5 31. A method of altering a useful torque in a drive train of a motor vehicle substantially as described herein with reference to and as illustrated in Figures 1 to 3 and 5 of the accompanying drawings.

10 32. A method of altering a useful torque in a drive train of a motor vehicle substantially as described herein with reference to and as illustrated in Figures 6a and 6b of the accompanying drawings.

15 33. A method of altering a useful torque in a drive train of a motor vehicle substantially as described herein with reference to and as illustrated in Figures 8a and 8b of the accompanying drawings.

34. Apparatus for altering a useful torque in a drive train of a motor vehicle substantially as described herein with reference to and as illustrated in Figures 1 and 2 of the accompanying drawings.



# The Patent Office

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Application No: GB 9620344.3  
Claims searched: 1-34

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## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.O): G3N NGA4, NGA9, NGE1, NGE1A, NGE1B; F2L LB.

Int CI (Ed.6): B60K 23/00, 23/02; F16D 48/06.

Other: ONLINE: CLAIMS, JAPIO, WPI.

### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2,229,244 A (AUTOMOTIVE PRODUCTS PLC)	
A	GB 2,196,057 A (DAIMLER BENZ AKTIENGESELLSCHAFT)	
A	WO 88/06234 A (MITSUBISHI DENKI KABUSHIKI KAISHA)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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